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Title: Airborne Ground Penetrating Radar (GPR) for Peat Analyses in the Canadian Northern Wetlands Study

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This study was conducted as part of the NASA Biospherics Research on Emissions from Wetlands (BREW) program in conjunction with the Global Tropospheric Experiment/Atmospheric Boundary Layer Experiment 3B (GTE/ABLE) of the Canadian Northern Wetlands in the Summer of 1990. An important aspect of the program is to investigate the terrestrial production and atmospheric distribution of methane and other gases contributing to global warming. High latitude wetlands are important ecosystems to consider because of their significant production of these gases, their global extent and, the anticipated severity of impact to these ecosystems if global warming occurs. Since the production of many of these gases is biogenic and originates in the soil it is valuable to understand the various soil parameters that impact this production. The distribution and the amount of the carbon source available for microbial metabolism are some of these parameters. In this study we attempted to determine peat depth and to characterize some of the stratigraphy within the peat profile using Ground Penetrating Radar (GPR).

The focal test site of the study was in the Hudson Bay Lowlands - near Moosonee, Ontario. Data was collected from an area extending from James Bay on the east, westward across the coastal marsh, further extending across a predominantly fen environment, and onward to a predominantly bog environment about 100 km inland. Over this distance the peat depth ranged from 0m at the coast to approximately 3m at the 100 km inland bog site.

Multi-kilometer transects of airborne (helicopter) GPR data were collected periodically along the 100 km distance from the coast inland so as to obtain a regional trend in peat depth and related parameters. Global Positioning System (GPS) data was simultaneously collected from the helicopter to properly georeference the GPR data. Additional 50m ground-based transects of GPR data were also collected as a source of ground truthing, as a calibration aid for the airborne data sets and, as a source of higher resolution data for characterizing the strata within the peat. In situ peat depth probing and soil characterizations from excavated soil pits were used to verify GPR findings.

Results from the ground-based data are quite good. Peat depth was determined with the GPR by identifying the interface between the peat and the older marine clays below due to the conductivity differential between them. GPR-determined peat depths corresponded very closely with in situ probing. The greatest discrepancy, yet minor, between GPR-determined depths

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and probing occurred in areas with significant above ground, unsaturated moss growth. Preliminary analysis demonstrated that the GPR was also able to delineate stratifications within the peat indicative of denser layers. These occurrences were generally supported by in situ probing and examination of the soil pits dug.

Airborne GPR data acquisition is very experimental but proved promising from preliminary analysis. GPR did a fair job in determining peat depth depending upon the helicopter height. When the sensor was within 3m-5m of the ground surface the data was fairly good; above that height the data decreased significantly in its capability to delineate peat depth. Airborne GPR however provided minimal within-peat strata characterization. Occasionally, peat depth responses and in many cases the within-peat strata responses were confounded by responses from ground surfaces, the helicopter or some other source. Shielding and other improvements in the engineering of the system will decrease these sources of interference in the future.

Various trends in peat depth persisted across differing spatial scales. On the regional scale, GPR data affirmed a trend with increasing peat depth from the coastal marsh environment to the bog. Within the bog environment it was difficult, from preliminary analyses, to discern a significant change in peat depth as we traveled further inland. There may be a controlling factor in the natural ecosystem preventing bog peat depth from increasing or we may not have sampled far enough inland. (This sampling was hindered by logistics and remoteness.) On a local scale, peat depth was much more spatially variable. Still, a trend persisted of relatively shallow peat depths near water bodies changing to greater depths as the landscape progressed to fen and bog and possibly to tree islands. This sequence of change may occur over distances of 50m but usually over greater distances. When these vertical determinations of peat depth are integrated with lateral classifications of land cover from more traditional forms of remotely sensed data models can be developed to estimate carbon source in these northern wetlands from peat volume calculations.

Some paleoecologists believe that the Hudson Bay Lowlands have undergone a series of plant community successions, especially on a local scale, over the past 5000 years. Evidence of denser material and woody tissue indicating forest growth can be identified at various depths in the peat from the soil pits dug. In many cases the GPR was able to identify changes in response with depth that were correlated with these strata. Therefore, GPR may prove to be a beneficial tool in paleoecological studies.